DESIGN OF AN ELEVATED ROADWAY FOR RELIEF OF TRAFFIC CONGESTION AT INTERSECTION OF RIVER AND FEDERAL STREETS, TROY, N. Y.

ROBERT B. MANLEY, LT. (j. g.) (CEC) U.S.N.

Thesis
M28

Thesis
M28

Postgraduate School.
U. S. Naval Academy,
Annapolis, Md.

Design
# of an
Elevated Roadway
for
Relief of Traffic Congestion
at
Intersection of River & Federal Streets, Troy, N. Y.

by

urleigh
Robert B. Manley
Lt.(j.g.) (CEC) USN

Submitted to the
Faculty of Rensselaer Polytechnic Institute
in partial fulfillment of the requirements for the
Degree of Master of Civil Engineering

Troy, New York
June, 1948

M28

TABLE OF CONTENTS

Preface

- Title Page
- Table of Contents 1
- Acknowledgements 2

Introduction

- Object 3
- Scope 4

Basic Considerations

Formulation of the Problem

  - Sketch 1 5
  - General Description 6
  - Chart 1 8
  - Choice of Solution 9
- Conclusions 15

Details of Design

- Procedure 16
- Road Design 17
  - Horizontal Curves 18
  - Vertical Profile 20
- Girder Design 21
  - Floor Slab Design 22
  - Stringer Design 24
  - Floor Beam Design 26
  - Design of Firder 28

Bibliography 32

Appendix 33

- Drawings
  - 1. General Plan
  - 2. Vertical Profile
  - 3. Cross Section of Roadway

G884

PREFACE

ACKNOWLEDGEMENTS

I wish to express my sincere thanks and appreciation to Professor H. O. Sharp for his interest and advice in the selection and working out of this problem, and to Mr. P. O. Ferris, Chief Engineer of the Delaware and Hudson Railroad, and his staff for their efforts in supplying me with pertinent information.

The problem was made available by the Engineers Office, City of Troy, New York. I wish to thank Mr. C. S. Crawley of that office for his aid in obtaining necessary information.

INTRODUCTION

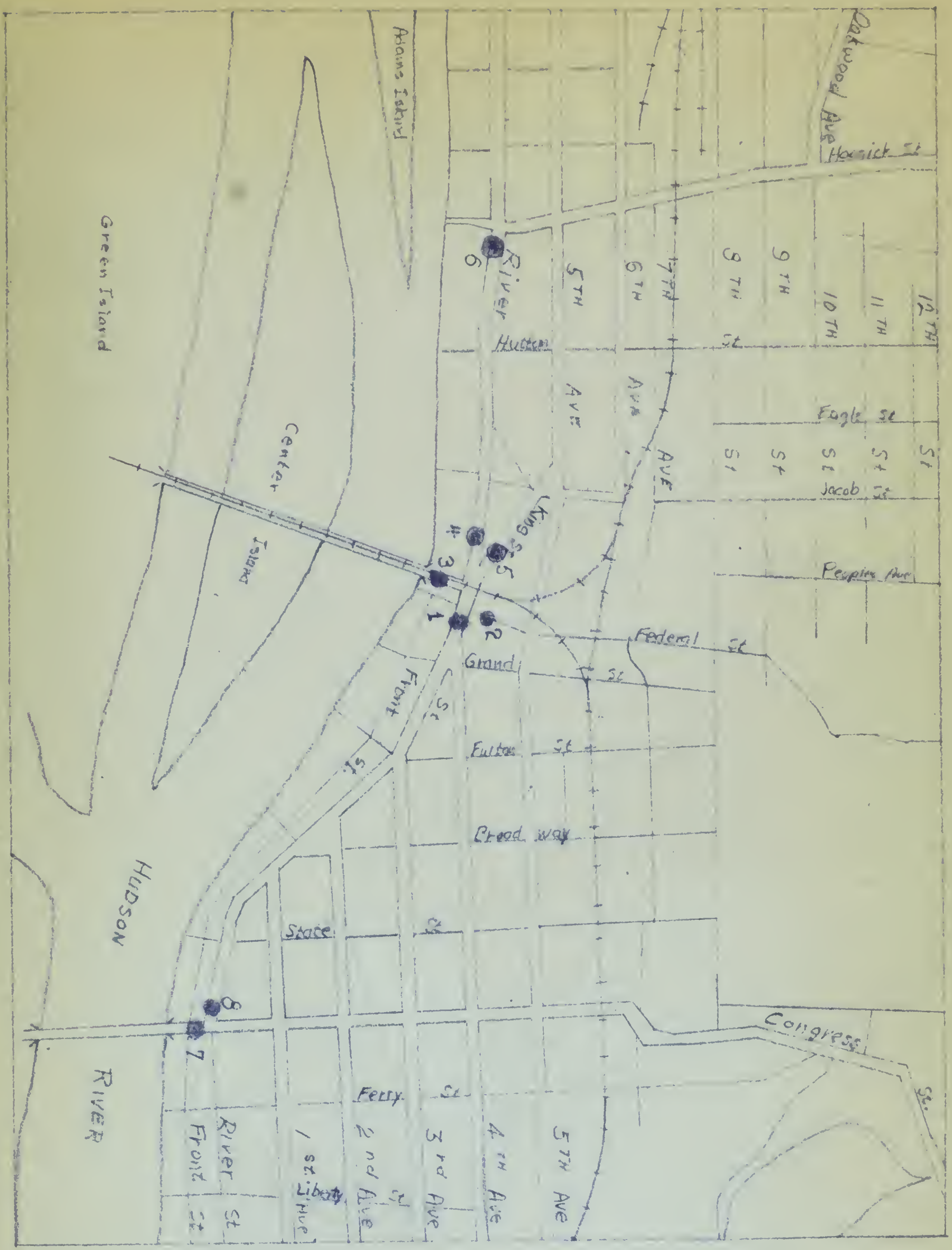
OBJECT

The purpose of this thesis is to analyze the traffic problem at the intersection of River and Federal Streets and the Troy terminus of the Green Island Bridge, and to present the design which I believe to be the most feasible economically to relieve the traffic congestion at this important arterial intersection.

SCOPE

The problem covered by this thesis is twofold. The first part, Traffic Analysis, must necessarily be based upon figures compiled during a recent twenty-four hour traffic survey by the Department of Public Works of the State of New York, as the personnel required limits such a survey to this or similar organizations. The second part, Design of an Elevated Roadway, is covered by the design of the salient feature of the roadway, the part spanning the Troy Union Railroad and River Street. The remainder of the design, though relatively simple, was left out because of the short time available. Furthermore, there was no attempt to make complete working drawings or calculate the cost of the entire project.

BASIC CONSIDERATIONS


Green Island
Adams Island
Center Island
HUDSON
RIVER
Oakwood Ave
Hoosick St
River
5TH Ave
6TH Ave
7TH AVE
9TH St
9TH St
10TH St
11TH St
12TH St
Hutton St
Eagle St
Jacob St
Peoples Ave
Kings St
Federal St
Grand St
Front St
St
Fulton St
Broadway
State St
Congress St
Ferry St
River St
Front St
1st Ave
Liberty St
2nd Ave
3rd Ave
4th Ave
5TH Ave
1
2
3
4
5
6
7
8

FORMULATION of the PROBLEM

General Description (See map, previous page)

The intersection chosen for this problem lies at the northern end of the central business district of the city of Troy, New York. It is formed by north-south traffic along River Street, one-way north-bound traffic along King Street, east-west traffic along Federal Street, and east-west traffic on the approach to the Troy- Green Island Bridge, which terminates on River Street just north of Federal Street. This bridge is maintained by the Troy Union Railroad, an amalgamation of the Boston & Main, the Delaware & Hudson, and the New York Central Railroads for the purpose of using a single track across the Hudson River into the city of Troy. The crossing is at street level, and is protected by a crossing guard and two sets of crossing arms.

Traffic along River Street and over the bridge is very heavy, especially during the morning and evening rush hours. The streets concerned are part of the statewide system of highways, but the largest proportion of vehicles are commuters between the residential districts of both Troy and Green Island

Station	Street	Traffic into City			Traffic out of City			24 Hour Total
		Cars	Buses	Trucks	Cars	Buses	Trucks	
1	River (So. Cor.)	400	43	107	335	12	91	10,375
2	Federal	251	40	31	112	0	33	3,455
3	Congress (Br.)	241	22	30	295	20	47	5,428
4	River (No. Cor.)	271	25	64	328	20	170	8,707
5	King	—	—	—	204	1	29	2,013
6	River (So. Cor.)	540	46	79	405	35	40	8,876
7	Green Isl. Br.	476	10	80	598	26	162	10,448
8	River (No. Cor.)	159	0	32	315	4	55	4,869

MAXIMUM HOURLY TRAFFIC
Sept. 28, 1948

and the many industries of both areas, including the Ford plant and other large factories. Interurban bus lines and truck routes also add to the total. (See chart next page) Traffic flow is permitted in any of the possible directions without the aid of control lights, although Federal Street does have through-traffic stop signs at River Street. A Troy policeman is stationed at the intersection during the rush hours to control directional flow, but the difficulties of his task are multiplied by the atrocious road manners of the majority of drivers in this part of the country.

The buildings in the locality of this intersection are for the most part old, two and three-story brick structures, with small stores on the ground floors and apartments or flats on the upper floors. A detailed property map is shown at the end of the thesis, with those properties that would be affected by the proposed elevated roadway. Street widths vary from 20 foot, two-lane pavements on King Street to 65 foot, four-lanes at the railroad crossing on River Street. The New York Power and Light Corporation and the New York Telephone Company own poles along the present streets, many of which would require removal for the proposed structure.

Choice of Solution

Any solution to the traffic problem at this intersection must meet one general condition; namely, rerouting a percentage of traffic away from the intersection. This could possibly be done by improving other existing roads and structures, thereby diverting more traffic to them; by building new roads and structures separate from existing ones and placed so as to divert a large percentage of the traffic; or by supplementing the present roads with structures to carry part of the traffic over or under the intersection along present routes. Following is a brief discussion of each of the three possibilities, with their advantages and disadvantages.

1. Improve other existing roads and structures. Streets running in a north-south direction which could possibly relieve River and King Streets include Fifth, Seventh, and Eighth Avenues, each running roughly parallel to River Street, to the east of River in the order named. These are all through, four-lane streets, with parking permitted in the outer lanes for the convenience of the residents of the apartments and houses which line all three. They carry a large volume of traffic at present,

and could be increased only by further widening, possible only through large scale condemnation proceedings, or by prohibiting parking on one or both sides. This measure would be very unpopular due to already strained parking facilities in this city.

Those streets carrying east-west traffic could only be effective in reducing congestion at the intersection in question if they end with a bridge across the Hudson River. This limits the choice to Congress Street, Federal Street ending near the Green Island Bridge, and Twelth Street in North Troy. Congress Street already carries too much traffic for its size, and requires policemen at each of the downtown corners during the rush hours to keep the vehicles moving. Therefore, anymore traffic diverted to this street would only strain already overcrowded conditions. The second, Federal Street, in conjunction with the Green Island Bridge, if improved would only add to the bad conditions previously described at this intersection. This, of course, assumes that other structures would not be built to supplement the improvements. The third alternative, Twelth Street, is located several

Station	Street	Traffic into City			Traffic out of City			24 Hour Total
		Cars	Buses	Trucks	Cars	Buses	Trucks	
1	River (So. Cor.)	400	43	107	335	12	91	10,375
2	Federal	251	40	31	112	0	33	3,455
3	Congress (Br.)	241	22	30	295	20	47	5,428
4	River (No. Cor.)	271	25	64	328	20	170	8,707
5	King	—	—	—	204	1	29	2,013
6	River (So. Cor.)	540	46	79	405	35	40	8,876
7	Green Isl. Br.	476	10	80	598	26	162	10,448
8	River (No. Cor.)	159	0	32	315	4	55	4,869

MAXIMUM HOURLY TRAFFIC
Sept. 28, 1948

Choice of Solution

Any solution to the traffic problem at this intersection must meet one general condition; namely, rerouting a percentage of traffic away from the intersection. This could possibly be done by improving other existing roads and structures, thereby diverting more traffic to them; by building new roads and structures separate from existing ones and placed so as to divert a large percentage of the traffic; or by supplementing the present roads with structures to carry part of the traffic over or under the intersection along present routes. Following is a brief discussion of each of the three possibilities, with their advantages and disadvantages.

1. Improve other existing roads and structures. Streets running in a north-south direction which could possibly relieve River and King Streets include Fifth, Seventh, and Eighth Avenues, each running roughly parallel to River Street, to the east of River in the order named. These are all through, four-lane streets, with parking permitted in the outer lanes for the convenience of the residents of the apartments and houses which line all three. They carry a large volume of traffic at present,

and could be increased only by further widening, possible only through large scale condemnation proceedings, or by prohibiting parking on one or both sides. This measure would be very unpopular due to already strained parking facilities in this city.

Those streets carrying east-west traffic could only be effective in reducing congestion at the intersection in question if they end with a bridge across the Hudson River. This limits the choice to Congress Street, Federal Street ending near the Green Island Bridge, and Twelth Street in North Troy. Congress Street already carries too much traffic for its size, and requires policemen at each of the downtown corners during the rush hours to keep the vehicles moving. Therefore, anymore traffic diverted to this street would only strain already overcrowded conditions. The second, Federal Street, in conjunction with the Green Island Bridge, if improved would only add to the bad conditions previously described at this intersection. This, of course, assumes that other structures would not be built to supplement the improvements. The third alternative, Twelth Street, is located several

miles to the north of Federal Street, and effectively serves that locality. However, that same location puts the bridge out of reach of the commutors which now use the Green Island Bridge.

The conclusion reached, therefore, is that improvement of existing roads and structures will not be effective unless other supplementary measures are also carried out.

2. Build new roads and structures separate from existing ones.

The question of relative economy is the prime consideration in this case. Any new route chosen in this locality would necessitate condemning riverfront property, which is largely covered by factories. The bridge itself would naturally be very costly, and would outweigh any savings made in time and money, presently lost in traffic congestions. Another viewpoint with respect to money outlay is that of taxpayers. Troy is located in a fairly stable population area. The city itself will probably expand in the outlying districts, with accompanying decline of the downtown residential areas. Therefore, any excessive outlay of money with accompanying bond issues would probably not be too popular or well received.

The conclusion reached here is that the construction of new roads and structures is not economically feasible and must be rejected.

3. Supplement present roads with an over- or underpass to divert traffic from the intersection.

A design was made several years ago in connection with a proposed modification of the r ail-road tracks through Troy which, if carried out, would have done away with this subject for a thesis. The tracks were to be raised so as to cross over River Street, and a ramp constructed to form an approach to the bridge along the western side of River Street. Federal Street was to have been closed off to through traffic. This design, although being very good as a part of the overall proposed change, is not applicable to our limited problem. It cannot be assumed that the railroads will raise their tracks for this one intersection, so an underpass along River Street is not practical. Therefore, an overpass appears to be the only alternative here. To keep the cost reasonably low, it is assumed that the present bridge will be used, with possible future widening if traffic volume increases so as to overcrowd the present roadway.

With an overpass in mind as the best practical solution, let us turn to the traffic survey conducted a year ago by the New York State Department of Public Works, to use as a criterion for locating the overpass. The total counts for pertinent streets are shown on a previous page. Points which should be noted are as follows:

a. The relatively small amount of traffic along King Street. This street should theoretically carry a larger percentage than it does at present due to its leading out to Fifth Avenue, away from the riverfront industrial area. However, practical limitations reduce its effectiveness. These are its narrow width when parking is allowed in one lane, its frequent blocking by trucks which deliver merchandise to the many stores, and the general disregard for parking regulations prevalent throughout Troy.

b. The large volume of north-south traffic along River Street. Any structure to relieve congestion along this main business street will result in an indirect savings for all types of commercial transportation facilities.

c. The large amount of traffic overcrowding the Congress Street Bridge. During the

rush hours there is one car every three seconds passing both ways aver this bridge. Increasing the capacity of the Green Island Bridge would probably draw traffic away from Congress Street, reducing the congestion there.

d. The relatively small amount of traffic away from the bridge along Federal Street compared to that along River and King Street. This amount of crossing traffic could easily be controlled by traffic signals if the others were diverted from the intersection.

The principal disadvantages to this design are that of restricting sunlight to the streets below, and exposing upper floors of buildings to the gazes of passing motorists. This problem has been met and overcome in the construction of similar roadways, such as the new one along Third Avenue in Brooklyn, and as there are no rules by which to evaluate the trouble caused by each, it must suffice to say that the conditions here would be no worse than corresponding conditions elsewhere.

Conclusions

The conclusion reached, after considering all the aspects of the problem, is to construct a one-way, two-lane elevated roadway from the Green Island Bridge across River Street, along King Street and down to River Street, with a ramp also leading down to Fifth Avenue at Jacob Street. The details of the design follow in the next sections.

DETAILS OF DESIGN

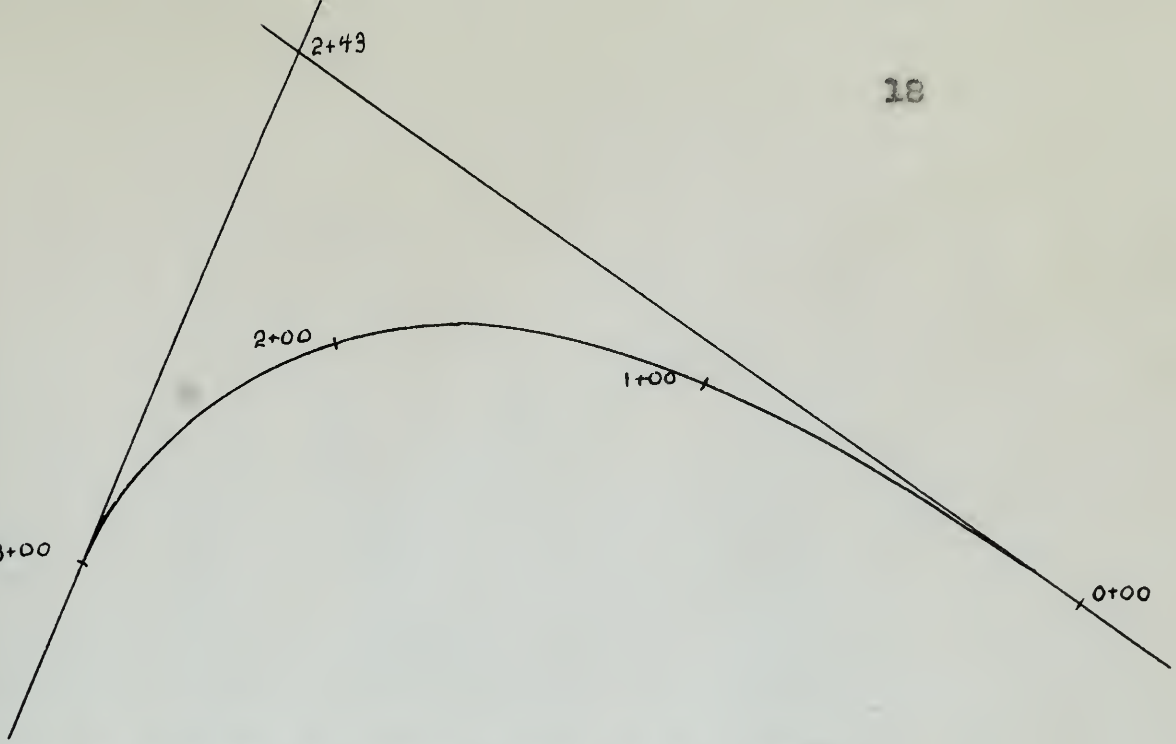
PROCEDURE

The detailed design will follow. First the chosen route will be laid out and the horizontal curves computed. Then the elevations will be determined, followed by the design of the girder section of the roadway.

ROAD DESIGN

The route chosen commences at the eastern end of the Troy- Green Island Bridge at an azimuth of 151° 20' and passes along a spiral and a circular curve to azimuth 048° 50' at station 3+00, the beginning of the girder section spanning the railroad. At station 8+13, circular curves lead a right-hand ramp down to Fifth Avenue, and the left-hand ramp to azimuth 247° 50', continuing along King Street across Jacob Street. A circular curve starting at station 12+13 carries the roadway around and down along azimuth 005° 50' to the exit on River Street at station 15+50.

Computations for horizontal curves follow.



Using $I = 102.5^\circ$, $D = 60^\circ$, $p = 17'$ and $R_c = 100'$

For spiral

$l_c = (24 \times 100 \times 17)^{\frac{1}{2}} = 202$ ft.

$S_c = \frac{202 \times 60}{200} = 60.5^\circ$

$X_c = 4/3 \times 100\ (1 - \cos 60.5^\circ) = 67.5$ ft.

$Y_c = 202 - \frac{(202)^2}{40\ (100)^2} = 201.9$ ft.

$i_c = \frac{60.5}{3}\quad 20.16\quad 1.26^\circ$

$i_{50} = \frac{(50)^2}{200} \times 20.16 = 1.26^\circ$

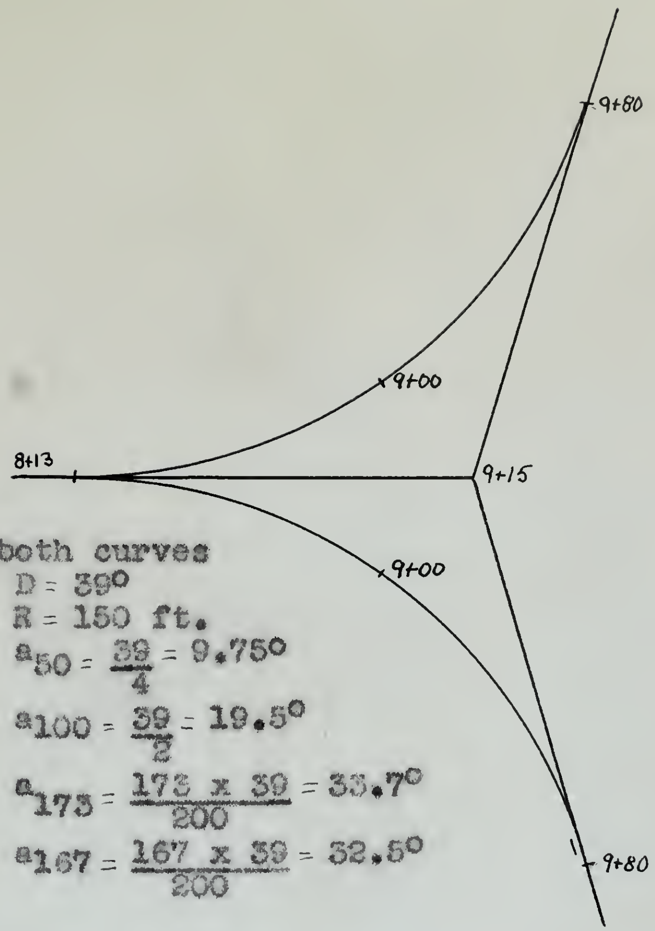
$i_{100} = 1/2 \times 20.16 = 5.04^\circ$

$i_{150} = 9/16 \times 20.16 = 11.36^\circ$

For curve

$a_{50} = \frac{50 \times 60}{200} = 15^\circ$

$a_{100} = \frac{60}{2} = 30^\circ$



For both curves

$D = 39^{\circ}$

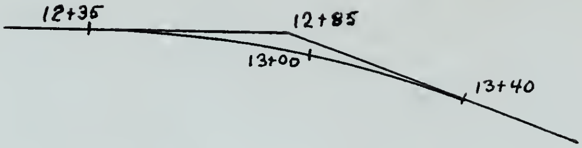
$R = 150$ ft.

$a_{50} = \frac{39}{4} = 9.75^{\circ}$

$a_{100} = \frac{39}{2} = 19.5^{\circ}$

$a_{173} = \frac{173 \times 39}{200} = 33.7^{\circ}$

$a_{167} = \frac{167 \times 39}{200} = 32.5^{\circ}$



$D = 20^{\circ}$

$R = 288$ ft.

$a_{50} = \frac{20}{4} = 5^{\circ}$

$a_{100} = \frac{20}{2} = 10^{\circ}$

$a_{123} = \frac{123 \times 20}{200} = 12.3^{\circ}$

VERTICAL PROFILE

The profile for this roadway has four points which must be met; namely, the elevation at the end of the bridge, that at a point giving twenty-two feet clearance over the railroad tracks, and those at the exits on Fifth Avenue and River Street. To obtain the actual elevation over the tracks, an additional height of three feet was added to the necessary clearance to allow room from the bottom of the girder to the top of the pavement. For final results, see drawing No. 2.

GIRDER DESIGN

Dimensions of Span

Span 80'-0
Dist. c. to c. of girders 24'-0
Dist. c. to c. of stringers 4'-0

Specifications

AASHO-1944

Loading

Live Load: H20-S16-44
Dead Load: As designed
Impact: As spec.

Connections

All steel connections welded

FLOOR SLAB DESIGN

1. Span

Assume 8" stringer flange width

$S = 4.0 - 4/12 = 3.66$ ft.

2. Dead Load

Assume 10" of concrete + 3" of bituminous

$D.L. = 3.66 \times 10/12 \times 150 + 3.66 \times 3/12 \times 105$

$= 457.5 + 96.1$

$= 553.6$ ppf

3. Effective Width

$E = 0.6 \times 3.66 + 2.5 = 4.7$ ft.

4. Total Bending Moment

Edge Strip

(a) Positive B.M.

$D.L. = \frac{553.6 \times 3.67}{14} = 145.2$ fp

$L.L. = \frac{.25 \times 16 \times 3.67}{4.7} = 3120$ fp

$Imp. = \frac{50}{3.66 \quad 125} = 38.9$ Use 30%

$I = 0.30 \times 3120 = \underline{937.5}$ fp

TOTAL $= 4202.7$ fp

(b) Negative B.M.

$D.L. = \frac{-554.6 \times 3.67}{10} = -202.5$ fp

$L.L. = \frac{-0.2 \times 16 \times 3.66}{4.7} = -2495.0$ fp

$I = -0.30 \times 2495 = \underline{-1748.5}$ fp

TOTAL $= -3446.0$ fp

Intermediate Strip

(a) Positive B.M.

$D.L. = \frac{553.6 \times 3.66}{16} = 126.2$ fp

$L.L. = \quad = 2495.0$ fp

$I = \quad \underline{748.5}$ fp

TOTAL $= 3369.7$ fp

(b) D.L. $= \dfrac{-553.6 \times 3.66}{12} = -168.5$ fp

L.L. $=$ -2495.0 fp

I $=$ -748.5 fp

TOTAL $= -3412.0$ fp

5. Reinforcement

Using $f_s = 18000$

$f_c = 1000$

$n = 10$

$$d^2 = \frac{M}{1890}$$

Edge Strip

$$d^2 = \frac{4202.7 \times 12}{1890} = 26.65$$

$d = 5.16$ Use $5\frac{1}{2}$"

$$A_s = \text{Pos.} = \frac{4202.7 \times 12}{18000 \times 0.881 \times 5.5} = 0.577 \text{ in}^2$$

$$A_s \ \text{Neg.} = \frac{3446 \times 12}{18000 \times 0.881 \times 5.5} = 0.473 \text{ in}^2$$

Pos. steel-Use 3/4"ø @ 9" spacing
Neg. steel-Use 3/4"ø @ 9" spacing,
@ 18" bend up one bar.

6. Distribution reinforcement

$$\% = \frac{100}{3.66^{\frac{1}{2}}} = 52.5\%$$

$A_s = 52.5\% \times 0.577 = 0.303 \text{ in.}^2$

Use $\frac{1}{2}$"ø @ $7\frac{1}{2}$" spacing

STRINGER DESIGN

1. Span 20'0

2. Dead Load moment

$$D.L. = 10/12 \times 4 \times 150 = 500 \text{ ppf}$$
$$Mom. = \frac{(500 \quad 50) \times 20^2}{8} = 28.0 \text{ fk}$$

3. Position of live load

$$0.586 \times 20 = 11.7 < 14$$
Put one wheel at center

4. Distribution factors

$$S = \frac{4.0}{5.0} = 0.80$$

5. Live load moment

$$Mom. = \frac{0.80 \times 16 \times 20}{4} = 64.0 \text{ fk}$$

6. Impact

$$I = 0.30 \times 64.0 = 19.2 \text{ fk}$$

7. Trial section

$$\text{Total Mom.} = 111.2 \text{ fk}$$
$$S = \frac{111.2 \times 12}{18} = 74.0 \text{ in}^3$$ Try 12 WF 58

8. Deflection check

$$d \text{ allow} = \frac{24 \times 12}{800} = 0.36 \text{ in.}$$
$$d \text{ max.} = (1 + 0.30) \quad \frac{16 \times 3 \times 1728}{24 \times 29 \times 10^6 \times 476.1} (3 \times 20^2 - 4 \times 3^2)$$
$$= 0.380 \text{ in. OK}$$

9. Stringer reaction

$$\text{L.L. R max.} = (1 + 0.30)\left[16 + 16 \times 1\ \frac{(20 - 14)}{24}\right] = 26.0\ \text{k}$$

$$\text{D.L. R max} = \frac{560 \times 20}{2} = 5.60\ \text{k}$$

$$\text{TOTAL R max} = 31.60\ \text{k}$$

10. Web shear check

$$V = \frac{31.60}{16 \times 0.4} = 4.93 < 11 \quad \text{OK} \quad \text{Use 16 WF 58}$$

11. Stiffeners

$$0.75 \times 11 = 8.25 \quad \text{No stiffeners required}$$

FLOOR BEAM DESIGN

1. Span 24'-0

2. Dead Load

$$
\begin{aligned}
\text{D.L.} &= 20\left[22 \times 10/12 + 2\,(1 \times 1)\right] = 150 \\
&\quad + 20 \times 20 \times 3/12 \times 140 + 5 \times 20 \times 56 + 24 \times 180 \\
&= 85.62 \text{ k}
\end{aligned}
$$

3. Dead Load moment

$$\text{D.L. Mom.} = \frac{85.62 \times 24}{8} = 256.86 \text{ fk}$$

4. Live Load reaction

$$
\begin{aligned}
\text{L.L.} &= 16 + 6/20\,(4 + 16) \\
&= 22 \text{ k}
\end{aligned}
$$

5. Live Load moment

$$
\begin{aligned}
R_r &= 1/24 \times 22\,(3 + 9 + 13 + 19) \\
&= 40.5 \text{ k} \\
\text{L.L. Mom.} &= 40.5 \times 11 - 22 \times 6 \\
&= 313.5 \text{ fk}
\end{aligned}
$$

6. Impact

$$\text{Imp. factor} = \frac{50}{24 + 125} = 33.5\% \text{ Use } 30\%$$

$$I = 0.30 \times 313.5 = 124.05 \text{ fk}$$

7. Trial section

Total Mom. = 694.4 fk

$$S = \frac{694.4 \times 12}{18} = 463 \text{ Try 27 WF 177}$$

8. Live Load shear

$$
\begin{aligned}
\text{L.L. V max.} &= 22/24\,(4 + 10 + 14 + 20) \\
&= 44 \text{ k}
\end{aligned}
$$

9. End reaction

$$R = 1.30 \times 44 + \frac{85.62}{2}$$

$$= 100.1 \text{ k}$$

10. Check of deflection

$$\text{Allow def.} = \frac{24 \times 12}{800} = 0.36 \text{ in.}$$

$$\text{def.} = 18/20 \times 0.44 = 0.39 \text{ in. OK}$$

11. $f = \frac{100.1}{27.31 \times 0.725} = 5.06 < 11$ OK Use 27 WF 177

DESIGN OF GIRDER

Conditions

Span 80'-0

Loads Uniform 300 ppf assumed for weight of girder. Concentrated loads of 100 k from floor beams welded to web at bottom flange.

Depth of web 6 ft.

Flange plates to be at least 16" wide. Depths and lengths to be determined.

Bottom flange supported laterally throughout.

A.I.S.C. and AASHO specifications followed where pertinent.

1. Maximum moment

$$R = \frac{300}{2} + \frac{0.3 \times 80}{2}$$

$$= 162 \text{ k}$$

$$\text{Max. mom.} = 162 \times 40 - 100 \times 20 - \frac{0.3 \times 40^2}{2}$$

$$= 4240 \text{ fk or } 50{,}880 \text{ ik}$$

2. Web thickness

1) $t = \dfrac{6.0 \times 12}{170} = 0.423$ in.

2) $A = t \times 6 \times 12 = \dfrac{162}{11} = 14.72 \text{ in}^2$

$t = \dfrac{14.72}{72} = 0.205$ in. Use 7/16" Pl.

3. Flange plates at center line

I of web $= 13608 \text{ in}^4$

Assume $t = 1\ 1/4$ in. A of plate = 20 sq. in.

3. I of flange = 2682 in^4 per sq. in.
= 53640 in^4
I TOTAL = 67248 in^4
Check: $I = \frac{50880 \times 37.25}{2} = 94.8$ in^4

Try t of web = 3/4 in.; t of flange = 1¼ in.; width = 18 in.
I of web = 23328
I of flange = 2701 in^4 per sq. in.
= 72900 in^4
I TOTAL = 96228
Check: $I = \frac{50880 \times 37.5}{20000} = 95300$ in^4
Use t of flange = 3/4 in.
t of web = 1¼ in.
width of web = 18 in.

4. Moments of inertia along girder

I at center line = 96228 in^4
I of 1¼" = 23328 + 22.5 x 2682.0
= 77328 in^4
I of 1" = 23328 + 13½ x 2665
= 71328 in^4
I of 3/21" = 23328 + 13½ x 2648
= 58928 in^4

5. Length of cover plates

Let d = dist. to end of plate closest to center line from end of girder
$M = 162d - 0.15d^2$, when $d \leq 20'$
$= 162d - 0.15d^2 - 100\,(d - 20)$, when $d > 20'$
$M = s \times f$
S of 1¼" $= \frac{77328}{37.25} = 2078$ in^3
S of 1" $= \frac{71328}{37.0} = 1932$ in^3
S of 3/4" $= \frac{58928}{36.5} = 1615$ in^3

1) Length of 3/4" plate

$$0.15d^2 - 162d + \frac{1615 \times 20}{12} = 0$$

$$d = \frac{162 + (162^2 - 4 \times 0.15 \times 2693)^{\frac{1}{2}}}{2 \times 0.15}$$

$d = 18.66$ ft. Use 18'-6
$L = 18'6''$
2) Length of 1" plate
$$0.15d^2 - 62d - 2000 = \frac{1932 \times 20}{12} = 0$$
$$0.15d^2 - 62d + 1220 = 0$$
$$d = \frac{62 \pm (62^2 - 4 \times 0.15 \times 1220)^{\frac{1}{2}}}{2 \times 0.15}$$
$= 20.33$ Use $d = 20'-4$
$L = 20.33 - 16.5 = 3'-10$
3) Length of $1\frac{1}{4}$" plate
$$0.15d^2 - 62d - 2000 + \frac{2078 \times 20}{12} = 0$$
$$0.15d^2 - 62d + 1460 = 0$$
$$d = \frac{62 \pm (62^2 - 4 \times 0.15 \times 1460)^{\frac{1}{2}}}{2 \times 0.15}$$
$= 25$ Use $d = 25'-0$
$L = 25.0 - 20.33 = 4'-8$

6. Intermediate stiffeners

$60\ t = 3/4 \times 60 = 45 < 72$ Must use stiffeners
Max. $V = \frac{162}{72 \times 3/4} = 3000$ psi
Use 6'-0 spacing
Assume ½" angles
Max width $= \frac{1}{2} \times 16 = 8''$
Min. width $= 2 + 72/30 = 4.4''$
Use 6" x 6" angles
$I_s = 0.00000016 \times 72^4 = 4.3\ \text{in}^4$
$I^s = 2\ (3/8 \times 6^3/12 + 3/8 \times 6 \times (3\ 7/32^2) = 60$ in.

7. Design of bearing stiffeners

Try 8 x 6 x ½" angles
Effective width $= 25 \times 3/4 = 18.76$ in. Use 18.75.
$$I = 18.75 \times \frac{(3/4)^3}{12} + 4\ (\tfrac{1}{2} \times \frac{8^3}{12} + 8 \times \tfrac{1}{2} \times 4.375^2)$$
$= 0.88 + 392.0$
$= 392.88$
$$r = \left(\frac{392.88}{18.75 \times 3/4 + 4 \times 8 \times \frac{1}{2}}\right)^{\frac{1}{2}}$$
$= 11.42$ in.
$l = 3/4 \times 72 = 54$ in.
$l/r = \frac{54}{11.42} = 4.72$
Allow $f = 17000 - 0.485 \times 4.72^2 = 16.99$ ksi
Actual $f = \frac{100}{4 \times 8 \times \frac{1}{2}} = 6.25$ ksi OK

8. Design of bearing plate

$A = \frac{162000}{600} = 270 \text{ in}^2.$

Use 20" width

Length $= \frac{270}{20} = 13.5$ in.

Use 15 in.

$n = \frac{20 - 0.75}{2} = 9.625$ in.

Use 10 in.

$p = \frac{162}{20 \times 15} = 0.54$ ksi

$t^2 = 0.15 \times 0.54 \times 10^2 = 8.1$

$t = 2.85''$

Use 15" x 3" x 1'-8" Plate.

BIBLIOGRAPHY

Allen, C. Frank, Railroad Curves and Earthwork, New York City, 1941, McGraw Hill Book Co.

American Association of State Highway Officials, Standard Specifications for Highway Bridges, and A Policy on Highway Types (Geometric), Washington, D. C., 1941, Published by the Association.

American Concrete Institute, Reinforced Concrete Design Handbook, Detroit, Michigan, 1941, Published by the Association.

American Institute of Steel Construction, Steel Construction, New York City, 1944, Published by the Institute.

Bruce, Arthur G., Highway Design and Construction. Scranton, Pennsylvania, 1942, International Textbook Co.

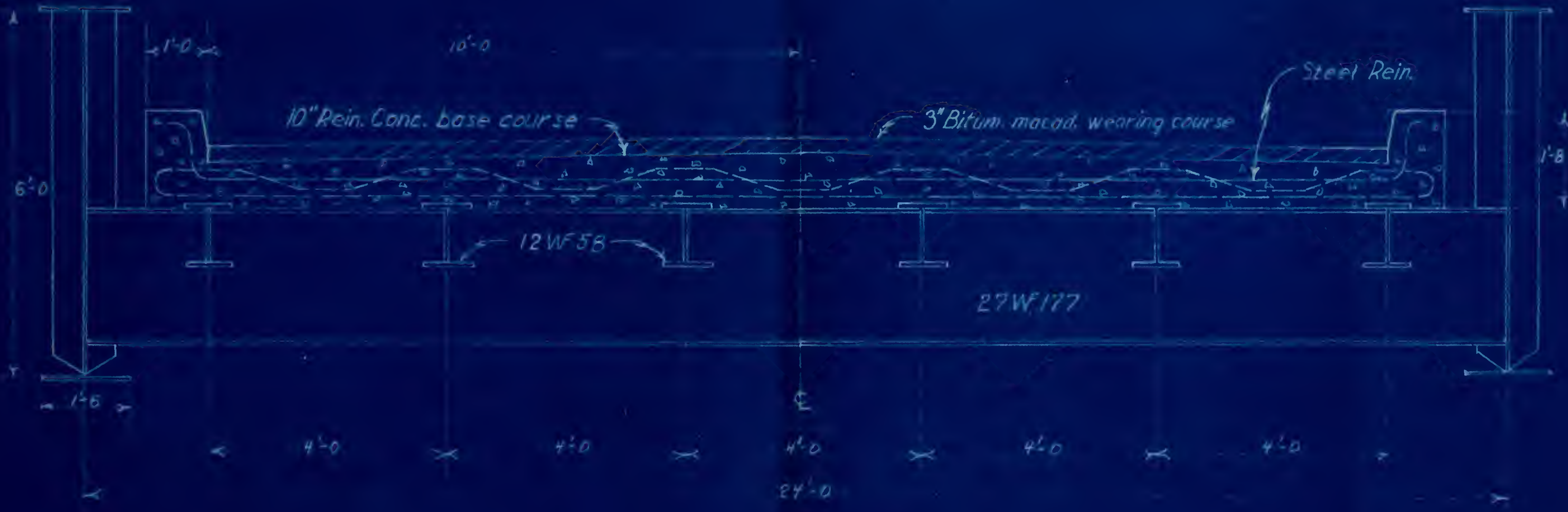
Dunham, C. L., Theory and Practice of Reinforced Concrete, New York City, 1939, McGraw Hill Book Co.

Ives, Howard C., Highway Curves, New York City, 1941, John Wiley and Sons, Inc.

Merriman, Thad, and Wiggin, T. H., American Civil Engineers Handbook, New York City, 1942, John Wiley and Sons, Inc.

APPENDIX

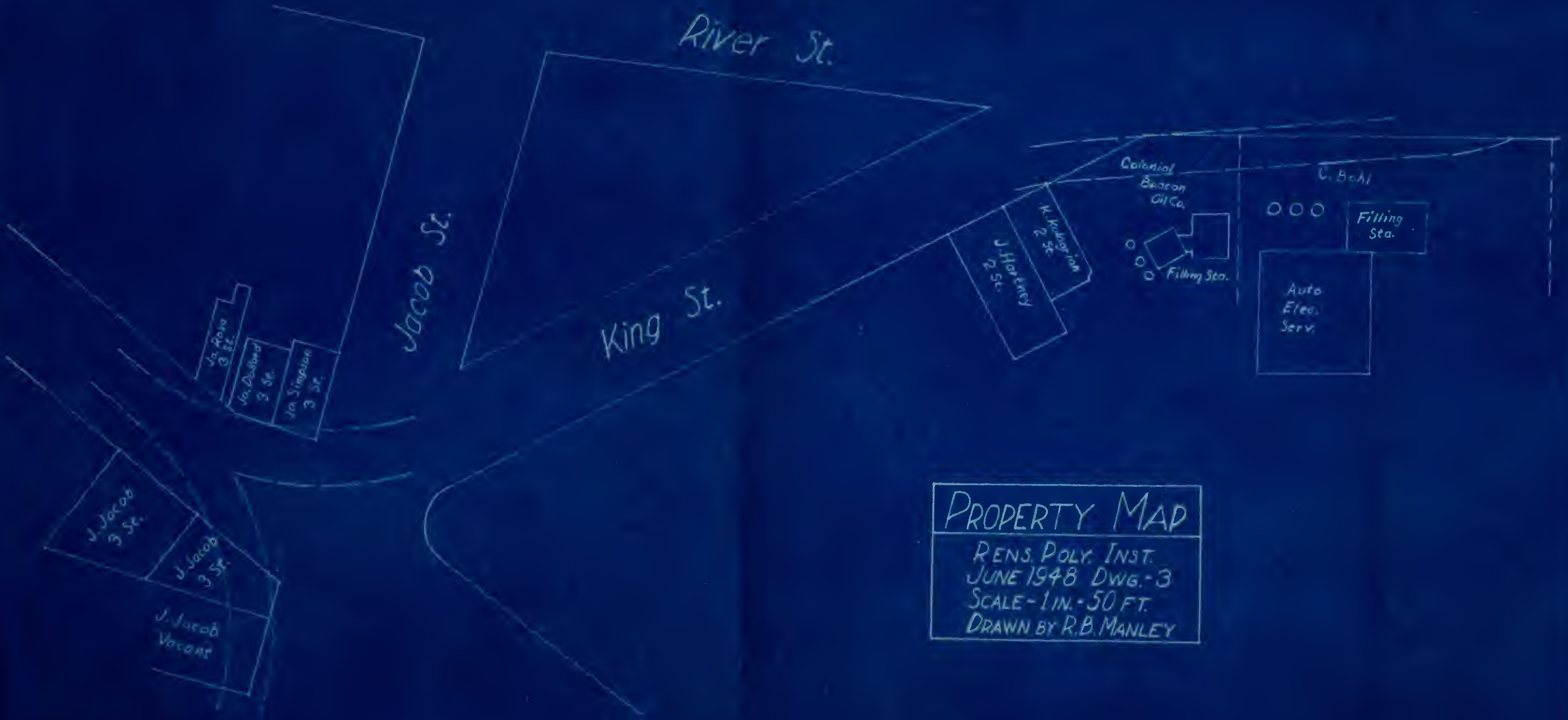
DWG-3



GIRDER SECTION

RENS. POLY. INST.
JUNE 1948 DWG. -3
SCALE - 1 IN. = 2 FT.
DR. BY R. B. MANLEY

DWG-3

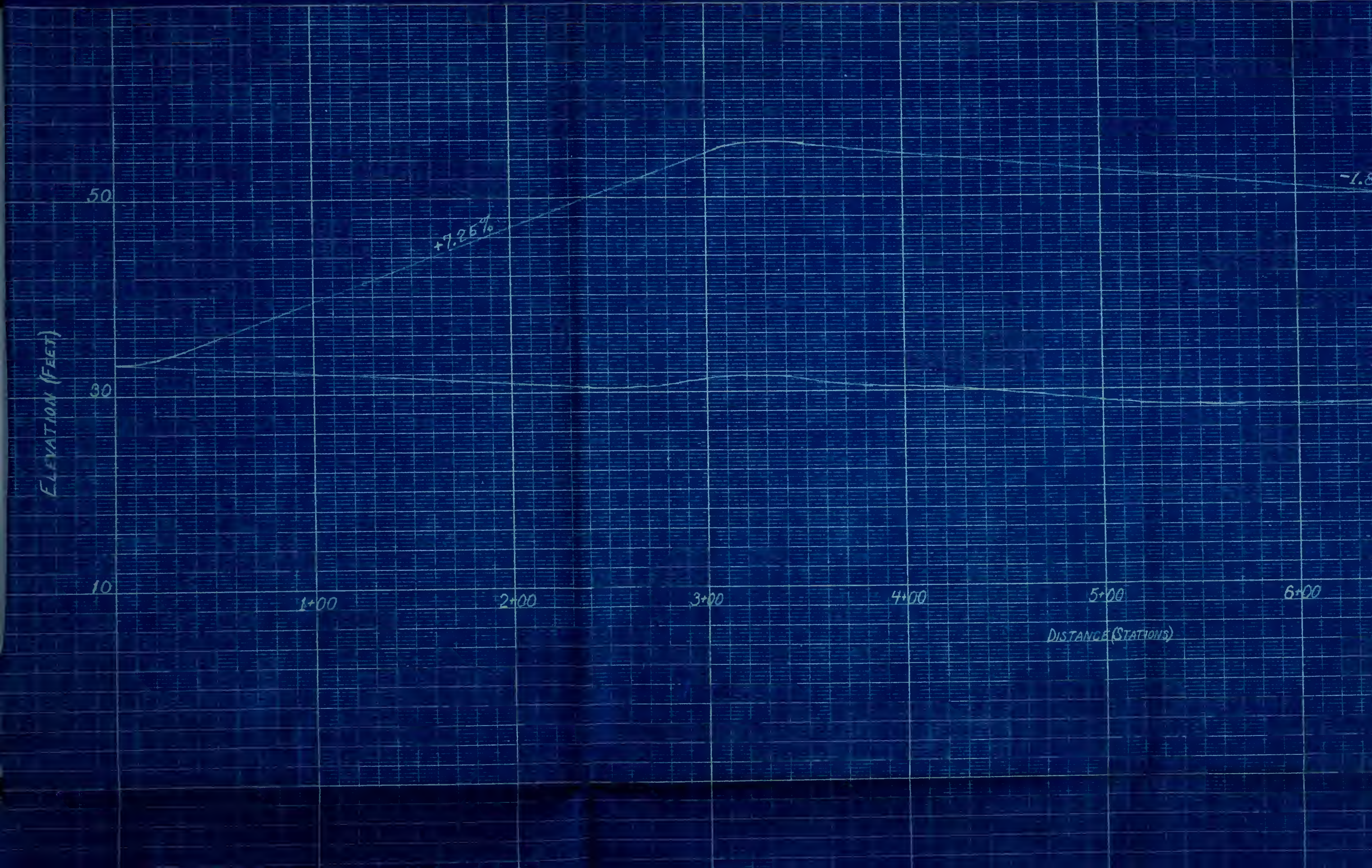


PROPERTY MAP

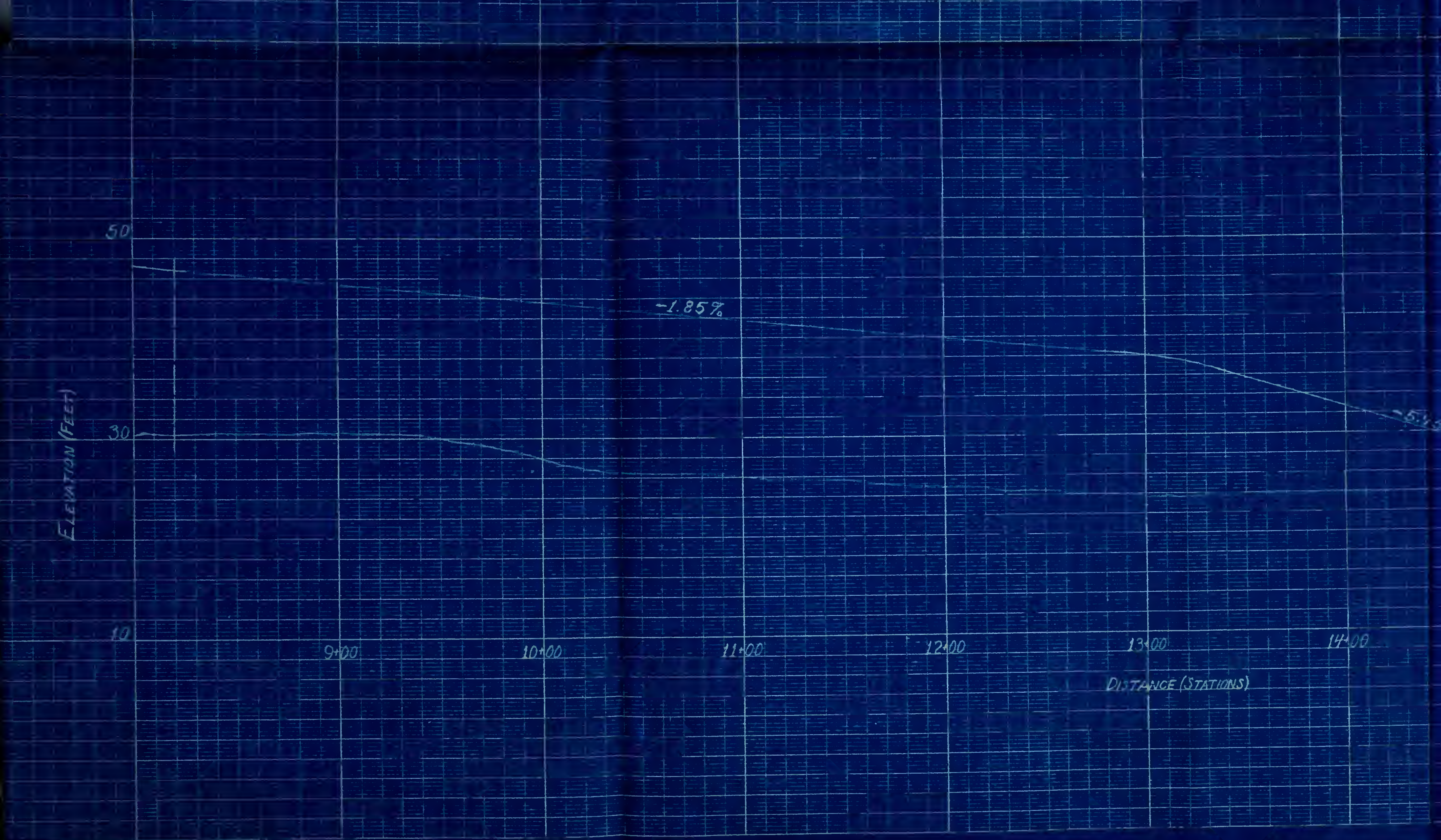
RENS. POLY. INST.
JUNE 1948 DWG.-3
SCALE-1 IN.-50 FT.
DRAWN BY R.B. MANLEY

GENERAL PLAN

RENS. POLY. INST.
JUNE 1948 DWG.-1
SCALE-1 IN.= 50 FT.
DRAWN BY R.B. MANLEY



+7.25%
-1.8
50
30
10
ELEVATION (FEET)
1+00
2+00
3+00
4+00
5+00
6+00
DISTANCE (STATIONS)

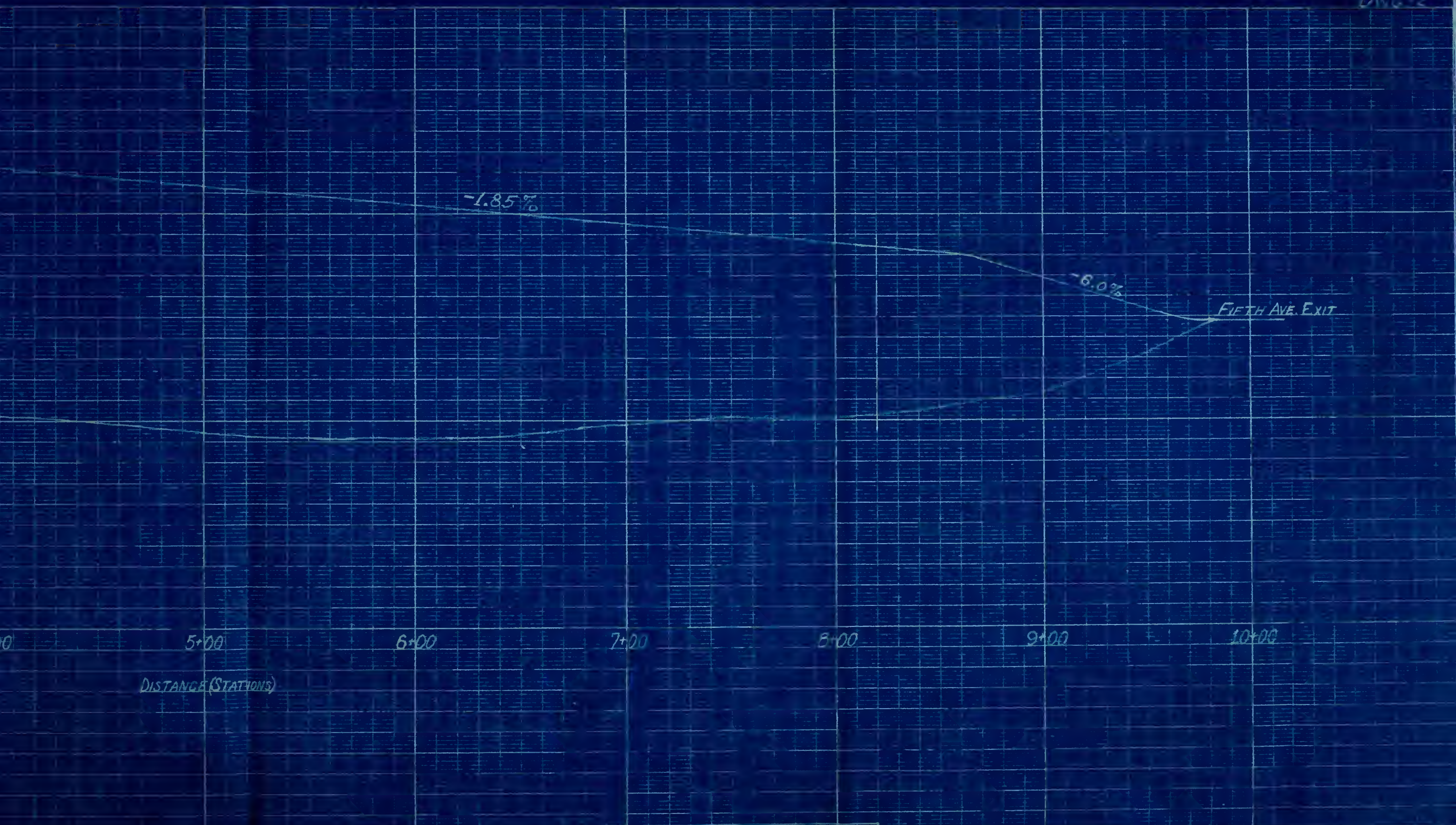


KEUFFEL & ESSER CO.
NEW YORK

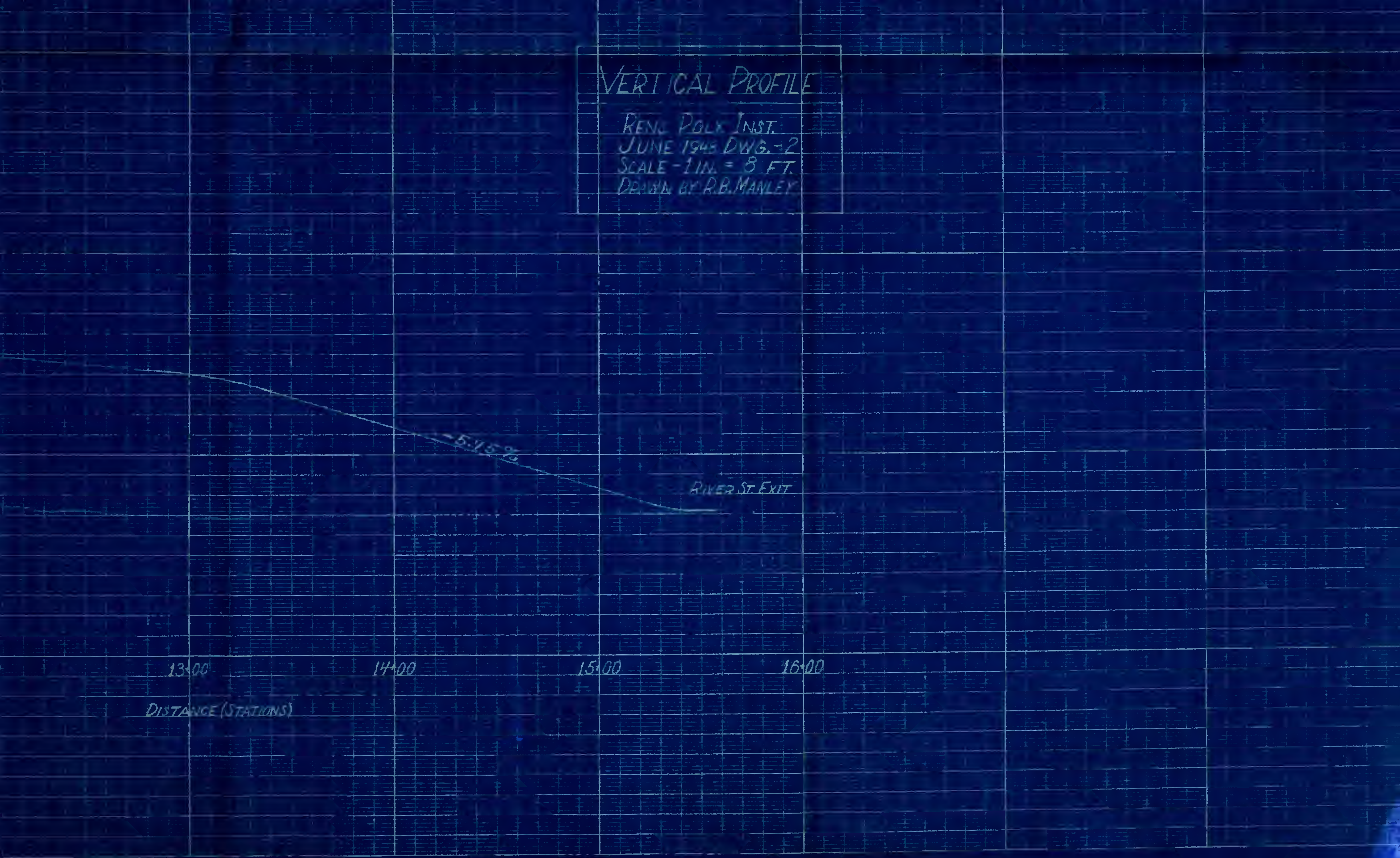
STANDARD
PROFILE PLATE

KEUFFEL & ESSER CO.
NEW YORK

Dwg-2



VERTICAL PROFILE



KEUFFEL & ESSER CO.

Thesis 6884
M28

Manley
Design of an elevated roadway for relief of traffic congestion at intersection of River and Federal streets, Troy, N. Y.

The
M28

De
li